Solar Cycle Studies for the Miniature X-ray Solar Spectrometer CubeSat Missions (MinXSS)

Completed Technology Project (2017 - 2021)

Project Introduction

OBJECTIVES. The Miniature X-ray Solar Spectrometer (MinXSS) program is a successful science CubeSat mission for the H-TIDeS LCAS program, and we propose to extend the MinXSS studies with a second launch in December 2016 with improved instrumentation for a new 4-year mission. The original MinXSS-1 mission objectives are to better understand the energy distribution of solar flare soft X-ray (SXR) emissions and its impact on Earth's ionosphere, thermosphere, and mesosphere (ITM). These studies, currently funded through 2016, focus on the solar SXR variability of active region evolution and flares during the MinXSS-1 six-month mission, modeling of the solar SXR variability, and understanding how the solar SXR energizes Earth's ionospheric E-region (80-150 km). The MinXSS-2 mission with its longer 4-year life will extend these studies during the declining phase of solar cycle 24, cycle minimum, and the rising phase of solar cycle 25. MinXSS will enhance these original studies during these different solar cycle phases by characterizing the differences in (1) the active region heating / abundance, (2) flare energetics, and (3) solar forcing in Earth's upper atmosphere. METHODOLOGY. MinXSS is a solar-oriented, 3-axis-controlled, 3-unit CubeSat to observe the solar SXR spectrum between 0.6 and 30 keV (0.04 and 2 nm). The X-ray spectrometer on MinXSS has a nominal spectral resolution of 0.15 keV full width half maximum (FWHM). The capabilities of this X-ray spectrometer have been flight-proven on MinXSS-1 and also previously on sounding rocket flights in 2012 and 2013. An improved version of this X-ray spectrometer is on MinXSS-2. The other major technology on MinXSS is the Attitude Determination and Control System (ADCS) from Blue Canyon Technologies (BCT); the BCT 0.5-unit ADCS has been flight proven on MinXSS-1 with precision solar pointing to ~10 arc-seconds. The MinXSS-1 was launched in December 2015 to the International Space Station (ISS) and deployed from the ISS on May 16, 2016. Starting from the ISS altitude of ~400 km, the MinXSS-1 mission life is only about 6 months. The MinXSS-2 spacecraft was built in parallel with MinXSS-1 and is being delivered to Spaceflight Industries in fall 2016 for its launch into a 500-km sun-synchronous orbit (SSO). This free ride-of-opportunity for MinXSS-2 from Google Terra Bella (formerly Skybox Imaging) was not planned in the original MinXSS program that only provides support for development of the MinXSS spacecraft and the MinXSS-1 mission through 2016. This proposal supports the new MinXSS-2 mission for two years (2017-2018) and an extended mission for two more years (or opportunity to be extended in the next Senior Review in 2017). As with MinXSS-1, closure on the science objectives involves comparisons with SDO and RHESSI measurements, ITM modeling using the NCAR Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Model (TIME-GCM), and improvements to the empirical Flare Irradiance Spectral Model (FISM) that is used for a variety of space weather research applications. New for MinXSS-2 is the addition of comparative studies with Hinode and NuSTAR solar measurements, studies correlating the measured photospheric magnetic field flux to soft X-ray spectra, and physics-based modeling of the SXR spectra. We

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Heliophysics Technology and Instrument Development for Science

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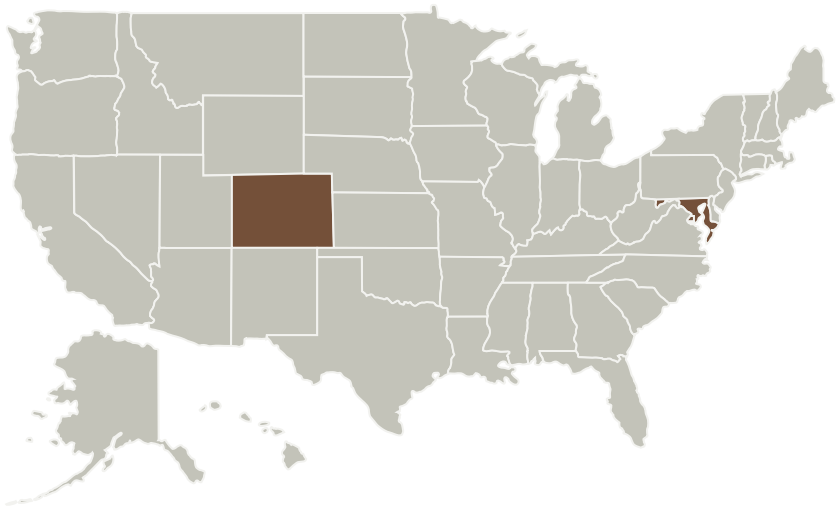
have added two more Co-Is for supporting the extra research, and we are also adding a second ground station at Geophysical Institute (GI) in Alaska for increasing the daily data downlink by a factor of six over MinXSS-1. We are willing to share LASP and GI ground stations with another NASA CubeSat.

Anticipated Benefits

Support NASA's strategic objectives to understand the Sun and its interactions with Earth and the solar system, including space weather. This will be achieved by developing/demonstrating instrumentation technology necessary to address the following science goals:

- Explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system;
- Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system;
- Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Colorado Boulder	Supporting Organization	Academia	Boulder, Colorado

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

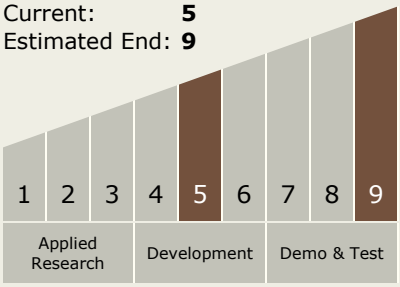
Thomas N Woods

Co-Investigators:

Amir Caspi
Phillip C Chamberlin
Andrew R Jones
Richard A Kohnert
James P Mason
Scott E Palo
Stanley C Solomon
Karen J Springfield
Harry P Warren

Technology Maturity (TRL)

Start: **5**
Current: **5**
Estimated End: **9**



Technology Areas

Primary:

- TX08 Sensors and Instruments

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Primary U.S. Work Locations	
Colorado	District of Columbia
Maryland	

Technology Areas *(cont.)*

- TX08.1 Remote Sensing Instruments/Sensors
  - TX08.1.1 Detectors and Focal Planes

Target Destination

The Sun